CLAIMS

1. A mechanism for gravity compensating a first rotatable member, comprising:

a first rotatable body, pivotable about a first axis, for rotating with the first rotatable member and having a first non-circular surface portion;

a second rotatable body, pivotable about a second axis, having a second non-circular surface portion; and

a first spring for biasing the second rotatable body in a rotation direction; wherein

the first and second rotatable bodies are arranged to rotate each other through the first and second non-circular surface portions.

2. A gravity compensating mechanism according to claim 1, wherein the first and second non-circular surface portions are arranged to rotate without relative slip.

3. A gravity compensating mechanism according to claim 1, wherein the first and second non-circular surface portions are arranged to rotate each other directly.

4. A gravity compensating mechanism according to claim 1, further comprising a flexible belt having two ends, one of the ends mounted on the first rotatable body and the other end mounted on the second rotatable body and the belt passing between the first and second rotatable bodies and through a plane containing the first and second axes.

5. A gravity compensating mechanism according to claim 1, wherein the first and second non-circular surface portions are sized and shaped such that the rotational torque of the first rotatable body, due to the spring, varies according to a cosine of a multiple of the angle of rotation of the first rotatable body.

6. A gravity compensating mechanism according to claim 1, further comprising said first rotatable member; wherein

the first rotatable body is mounted to rotate as the first member rotates; and

the first and second non-circular surface portions are sized and shaped and the first spring has a property such the torque on the first member provided through the first rotatable body compensates for gravity on the first member.

7. A gravity compensating mechanism according to claim 6, further comprising a first cable having two ends; and wherein

the first member is mounted on a third pivot axis and the first rotatable body is connected to rotate with the first member by way of the first cable.

8. A gravity compensating mechanism according to claim 7, further comprising a first circular surface portion arranged to rotate with the first rotatable body; and

wherein one end of the cable is connected to the first member and the other end is connected to said first circular surface portion.

9. A gravity compensating mechanism according to claim 8, wherein the first circular surface portion is integral with the first rotatable body.

10. A gravity compensating mechanism according to claim 8, wherein the first circular surface portion is arranged to rotate with the first rotatable body through a gear mechanism.

11. A gravity compensating mechanism according to claim 1, wherein the first spring is a linear spring having two ends.

12. A gravity compensating mechanism according to claim 1, further comprising a second circular surface portion arranged to rotate with the second rotatable body; and

wherein one end of the first spring is connected to said second circular surface portion.

13. A gravity compensating mechanism according to claim 7, further comprising a third circular surface portion mounted to rotate with the first member on the third pivot axis; and

wherein one end of the cable is connected to the third circular surface portion to pull in or pay out the first cable as the third circular surface portion rotates.

14. A gravity compensating mechanism according to claim 1, wherein the first rotatable member is an arm.

15. A gravity compensating mechanism according to claim 1, further comprising:

a third rotatable body for rotating about a third pivot axis and providing a torque for gravity compensating a second member, the third rotatable body having a third non-circular surface portion;

a fourth rotatable body for rotating about a fourth pivot axis and having a fourth non-circular surface portion; and

a second spring for biasing the fourth rotatable body in a rotation direction; wherein

the third and fourth rotatable bodies are arranged to rotate each other through the third and fourth non-circular surface portions.

16. A gravity compensating mechanism according to claim 15, further comprising:

a rotatable first member; and

a rotatable second member; and wherein

the first rotatable body is arranged to rotate with the first member;

the third rotatable body is arranged to rotate with the second member;

the first and second non-circular surface portions are sized and shaped and the first spring has a property such the torque on the first member provided through the first rotatable body compensates for gravity on the first member; and

the third and fourth non-circular surface portions are sized and shaped and the second spring has a property such the torque on the second member provided through the third rotatable body compensates for gravity on the second member.

17. A gravity compensating mechanism according to claim 16, further comprising:

a first cable having two ends;

a second cable having two ends;

a first circular surface portion mounted to rotate with the first member; and

a second circular surface portion mounted to rotate with the second member; wherein

one end of the first cable is connected to the first circular surface portion to pull in or pay out the first cable as the first circular surface portion rotates with the first member and the first rotatable body is connected to rotate with the first member by way of the first cable; and

one end of the second cable is connected to the second circular surface portion to pull in or pay out the second cable as the second circular surface portion rotates with the second member and the second rotatable body is connected to rotate with the second member by way of the second cable.

18. A gravity compensating mechanism according to claim 17, further comprising:

one or more additional members rotatably connected in series on the second member;

an additional two rotatable bodies for each additional rotatable member;

an additional cable for each additional rotatable member; and

an additional circular surface portion mounted to rotate with each additional member; wherein

one end of each additional cable is attached to a respective additional circular surface portion; and

the second end of each additional cable is attached to a rotatable body of the respective additional two rotatable bodies.

19. A gravity compensated rotatable member system comprising:

a rotatably mounted first member;

a spring biased first rotatable body mounted to rotate about a first pivot axis and having a first non-circular surface portion;

a first circular surface portion mounted to rotate with the first member; and

a first cable connected to the first circular surface portion to pull in or pay out the first cable as the first circular surface portion rotates; wherein

the first rotatable body is connected to rotate with the first member by way of the first cable; and

the spring biased rotatable body is shaped such that the torque on the first circular surface portion due to the tension in the first cable compensates for the moment on the first member due to gravity.

20. A gravity compensated rotatable member system comprising:

a plurality of members rotatably mounted in series, one on the other;

a plurality of spring biased first rotatable bodies, one associated with each member and each having a first non-circular surface portion;

a plurality of first circular surface portions, one associated with each member and mounted to rotate therewith;

one or more second circular surface portions associated with each member, one second circular surface portion associated with each member mounted to rotate with each member preceding that member in the series; and

a plurality of first cables, one associated with each member and connected to the first circular surface portion of the member with which it is associated, to pull in or pay out the first cable as the first circular surface portion rotates; wherein

each first rotatable body is connected to rotate with its associated member by way of a first cable;

each cable passes over every second circular surface portion associated with the member with which it is associated and transmits the tension in the cable as a torque to the members with which those second circular surface portions rotate, through those second circular surface portions; and

the spring biased first rotatable bodies are shaped such that the combined torques on the members from the first and second circular surface portions, due to the tensions in the first cables, compensate for the moments on the members due to gravity.

21. A rotatable body rotatable about an axis and having a non-circular surface portion, wherein the non-circular surface portion forms at least a portion of a curve which satisfies the equation

$$R1 = B * C * (CosA1) / \{C * (CosA1) \pm D * \sqrt{[E^2 + 2 * F * C * (SinA1)]}\},$$

where R1 is the distance from the axis, A1 is the angle of rotation of the body and B, C, D, E and F are constants.

22. A rotatable body rotatable about an axis and having a non-circular surface portion, wherein the non-circular surface portion forms at least a portion of a curve which satisfies the equation

$$R2 = (B * D * (E + F * A2)) / (D) * (E + F * A2) + C * (CosA1))$$

where R2 is the distance from the axis, A2 is the angle of rotation of the body B, C, D, E and F are constants and where A1 satisfies the equation

$$(SinA1) = A2 * (A2 * F + 2 * E) / 2 * C$$

23. A mechanism comprising:

a first rotatable body, pivotable about a first axis, having a first non-circular surface portion; and

a second rotatable body, pivotable about a second axis, having a second non-circular surface portion;

wherein the first and second non-circular surface portions rotate with each other, such that the angle of rotation A2 of the second body is related to the angle of rotation A1 of the first body by

$$A2 = \{- E \pm \sqrt{[E^2 + 2 * F * C * (SinA1)]}\} / F,$$

where C, E and F are constants.